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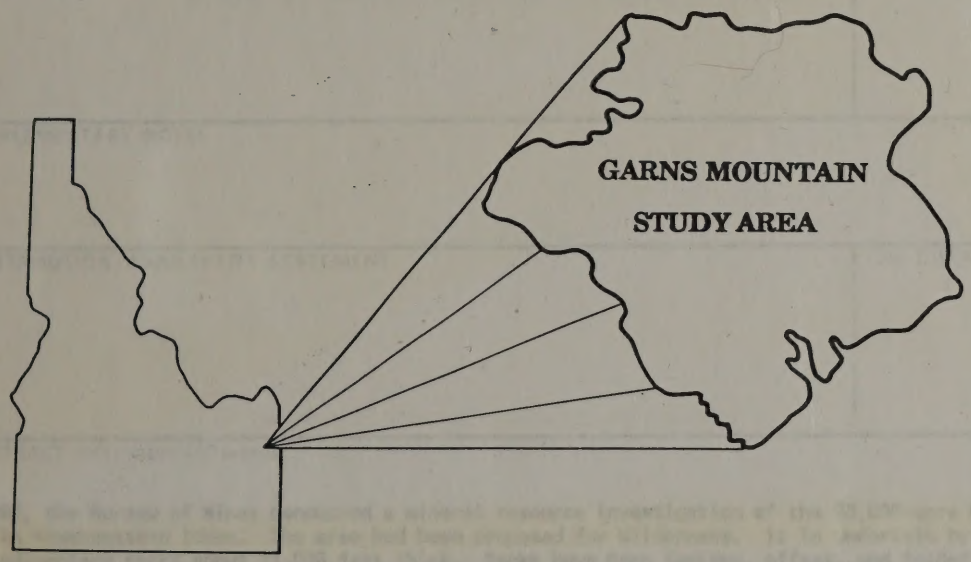
Mineral Resource Investigation of the Garns Mountain Study Area, Bonneville, Madison, and Teton Counties, Idaho



BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

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In 1992, the Bureau of Mines conducted a mineral resource investigation of the 78,000-acre Garns Mountain study area in southeastern Idaho. The area had been proposed for Wilderness. It is underlain by Paleozoic- to Mesozoic-age sedimentary rocks about 11,000 feet thick. Rocks have been faulted, offset, and folded as part of the northerly-trending Idaho-Wyoming Overthrust Belt.

Study area mineral occurrences are: phosphate in the Permian Phosphoria Formation; coal in the Cretaceous Frontier and Bear River Formations; and uranium in carbonaceous and phosphate-bearing shales and coal of these formations. Four zones of phosphate are estimated to contain about 528 million tons of rock with over 10% P_2O_5; samples of phosphate-rich rock also contained as much as 3950 ppm chromium, 3280 ppm vanadium, 23 ppm gallium, and 5540 ppm zinc. Fragments of poor-quality coal and carbonaceous shale were found in the area; coal was mined near the northeast border. Uranium content up to 0.016% U_3O_8 is in carbon-rich shales. Oil and gas were drilled for, with minimal success, in folded sedimentary rocks (Frontier and Nugget Sandstone) in the Horseshoe anticline, near the east border.

Examined workings included 12 dozer cuts, 4 trenches, 2 prospect pits, and 2 caved adits. No production is known, and no leases or claims are held for the area.

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MINERAL RESOURCE INVESTIGATION OF THE GARNS MOUNTAIN STUDY AREA, BONNEVILLE, MADISON, AND TETON COUNTIES, IDAHO

By
Frank E. Federspiel and Richard L. Rains

MLA 19-92

Western Field Operations Center
Spokane, Washington

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PREFACE

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Bureau of Mines and U.S. Geological Survey to survey certain areas of Federal land ". . . to determine the mineral values, if any, that may be present . . ." Results must be made available to the Public and be submitted to the President and the Congress. This report presents the results of a Bureau of Mines mineral investigation of the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho, which was classified as a Non-Wilderness Recommended Area during the Second Roadless Area Review and Evaluation (RARE II) by the Forest Service in 1979. Subsequent legislative proposals have recommended portions of the study area be classified as Wilderness; currently the area is not under Wilderness consideration. Mining-related activities in the study area, under Wilderness or Special Management classification, would be severely restricted.

This open-file report contains data gathered and interpreted by personnel of the U.S. Bureau of Mines, Western Field Operations Center, Branch of Resource Evaluation, East 360 Third Avenue, Spokane, Washington 99202. This report has been approved by the Branch of Mineral Land Assessment, Washington, D.C.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

British thermal unit	Btu
degree	°
foot	ft
mile	mi
part per billion	ppb
part per million	ppm
percent	%
pound	lb

SUMMARY

In 1992, the USBM (U.S. Bureau of Mines) examined the 78,000-acre Garns Mountain study area to evaluate its mineral resources. The area includes the Non-Wilderness Recommended RARE II Area No. 4-611. The study area is in Targhee National Forest, at the intersection of Bonneville, Madison, and Teton Counties, Idaho, approximately 40 air miles east of Idaho Falls and 10 miles west of Driggs.

Three mineral commodities have been identified in the study area: phosphate, coal, and uranium (the latter associated with phosphatic shale and coal). Oil and gas have been explored for just east of the study area.

Phosphate has been mined continuously in Idaho since 1909. Phosphate was likely mined from one study area property and another property near the eastern border; however, no records are available. Phosphate beds in the area have been examined by various individuals as early as 1910. Previous USBM engineers have estimated that four zones, mostly within the area, contain a total of approximately 528 million tons of resources averaging from plus 10% to plus 31% P_2O_5. Samples of phosphate-bearing rocks taken during this study contained between 5.85% and 37.60% P_2O_5, and as high as 3950 ppm (0.40%) chromium, 3280 ppm (0.33%) vanadium, 23 ppm (0.0023%) gallium, and 5440 ppm (0.54%) zinc.

Coal mines lie near the northeast corner of the study area in the Horseshoe Basin mining district, which overlaps the area boundary. Coal was mined intermittently between 1901 and the early 1950's. State of Idaho geologists have estimated approximately 11 million tons of coal are in beds north of the area. The coal has heating values of 11,000 to 14,000 Btus, with low sulfur and ash content.

Uranium occurs in carbonaceous shales, usually with associated phosphatic shales and coal, along the northeast and southeast borders of the area. Samples contained from 1 ppm to 160 ppm (0.0001% to 0.016%) U_3O_8 across 4-to 19-ft-thick sections. Some faulted shales contain significant concentrations of zinc.

The Western Overthrust Belt has been an exploration target for oil and gas since the late 1800's. A portion of the 2,200-mile-long belt, known as the Idaho-Wyoming Overthrust Belt, consists of sedimentary rocks of the Frontier and Nugget Formations, which are oil- and gas-producing units in adjacent states. These units are faulted and folded in and near the study area. Nine holes have been drilled east of the area in search of structural traps. Most holes have revealed only minor oil or gas shows; all holes have been plugged and abandoned.

INTRODUCTION

This report describes the USBM work to evaluate mineral resources of the Garns Mountain study area. The area was proposed as Wilderness in U.S. House Bills (100th and 101st Congress). The USBM examined mines, prospects, and mineralized zones. Results of this investigation will be used to help determine the suitability of the study area for inclusion into the National Wilderness Preservation System. Although the immediate goal of this and other USBM mineral surveys is to provide data for the President, Congress, government agencies, and the Public, for land-use decisions, the long-term objective is to ensure that the Nation has an adequate and dependable supply of minerals at a reasonable economic and environmental cost.

Setting

The Garns Mountain study area, in southeastern Idaho, encompasses 78,000 acres of lands administered by the Targhee National Forest. The main core of the Snake River Range is in the central portion of the area; the Big Hole Mountains, included in the Snake River Range, lie along the eastern boundary; and the Snake River Plain lies to the southwest. The area is situated about 40 air mi east of Idaho Falls and 10 mi west of Driggs (fig. 1). Access to its borders is mostly by graveled and maintained dirt roads from Idaho State Highways 31 and 33 (fig. 2). Pack trails follow major drainages and most ridges.

Piney Peak, at 9,019 ft, is the highest point in the study area, and elevations fall to 5,200 ft near the mouth of Mud Creek along the west central border. Higher elevations are occupied by alpine meadows and sparse pine and fir; lower elevations are covered by fir, pine, and aspen. The topography is steep to rolling. Summer months are warm and dry, with minimal rain; winters are usually harsh, with snow packs up to 20-ft thick very common above 7,000 ft.

Previous Studies

The earliest geological study of the Garns Mountain study area was by Bradley (1873), who lead a crew as a member of the Hayden Survey. The geology and economic possibilities of phosphate, coal, and oil and gas in and near the area were reported by numerous authors. Phosphate occurrences were principally described by Blackwelder (1911), Gardner (1944), Coffman and Service (1967), and Powell (1974). Coal studies were by Woodruff (1914), Evans (1919, and 1924), Mansfield (1920), Staley (1945), Andrews and others (1947), and Kiilsgaard (1951). Schultz (1918) did reconnaissance work on phosphate and coal. The Western Overthrust Belt has been of great interest for oil and gas potential; most relevant assessments of these energy sources for the area have been by Powers (1983), and Sandberg (1983).

Geologic maps of portions of the study area have been prepared by Staatz and Albee (1963, and 1966), Albee (1964), Pampeyan and others (1967), and Mitchell and Bennett (1979). Mitchell and others (1981) compiled maps showing mines and prospects within the Driggs Quadrangle. The geology and mineral resources of Bonneville County, which covers part of the study area, were described by Savage (1961). Theses describing the geology of portions of the area have been written by Andrau (1958), Espach (1957), Royse (1957), and Sorensen (1961).

Present Study

Prefield work included research of available geologic and mineral resource literature and a search of BLM (U.S. Bureau of Land Management) mining claim and lease records. A BLM office, and U.S. Forest Service District and Supervisor offices, were visited to obtain geological data, access routes, and other information pertinent to the study.

Field examinations were conducted in 1992. Mines, prospects, and mineral occurrences in the study area, or along the border, were sampled. Twenty-five rock samples were collected; these were of four types: (1) chip - a regular series of rock chips taken in a continuous line across a mineralized zone or other exposure; (2) random chip - an unsystematic series of chips taken from an exposure of apparently homogeneous rock; (3) grab - rock pieces collected unsystematically from a prospect dump or of float; (4) select - an intentionally biased selection of rock taken because of a unique or unusual property.

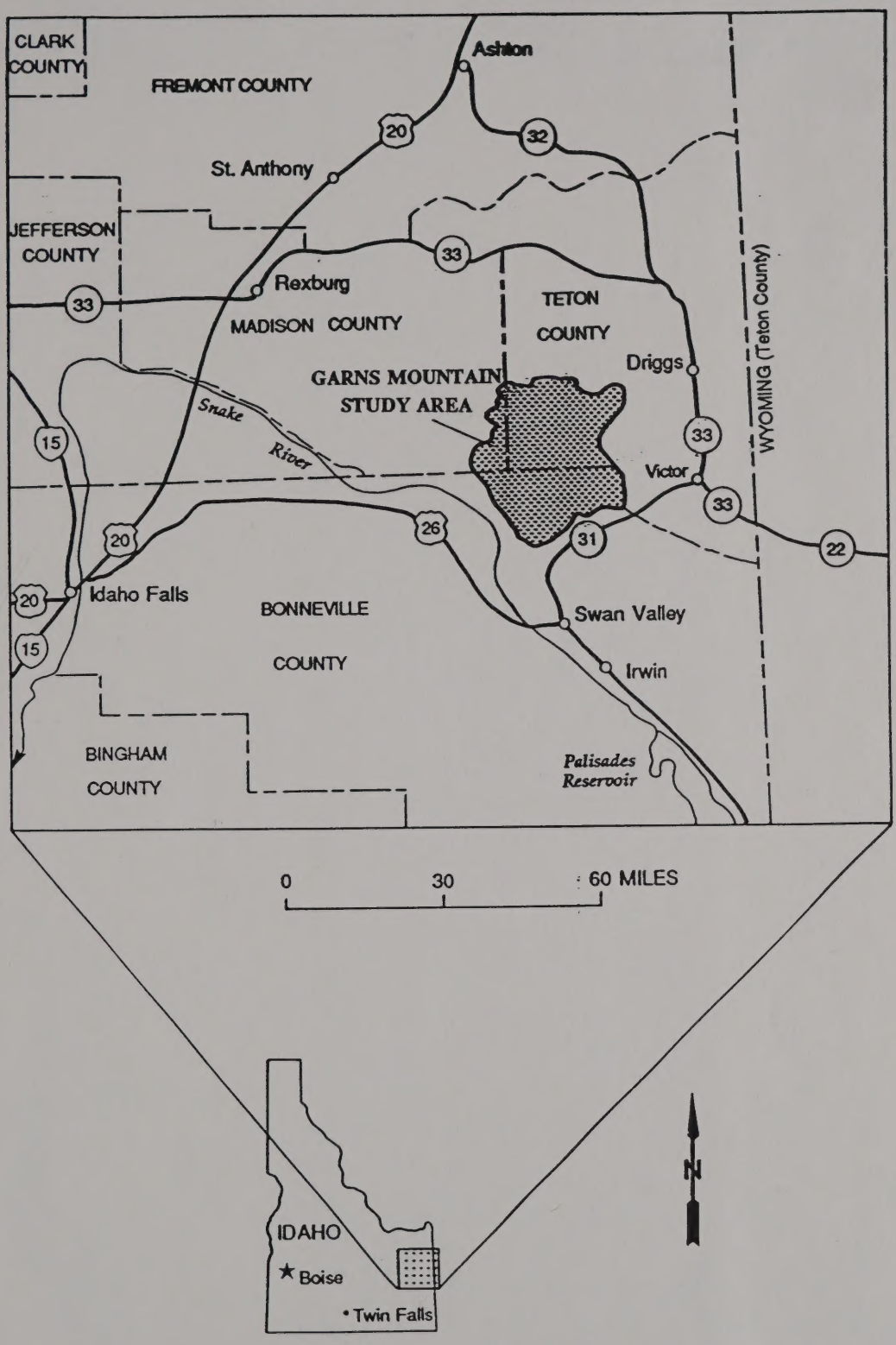
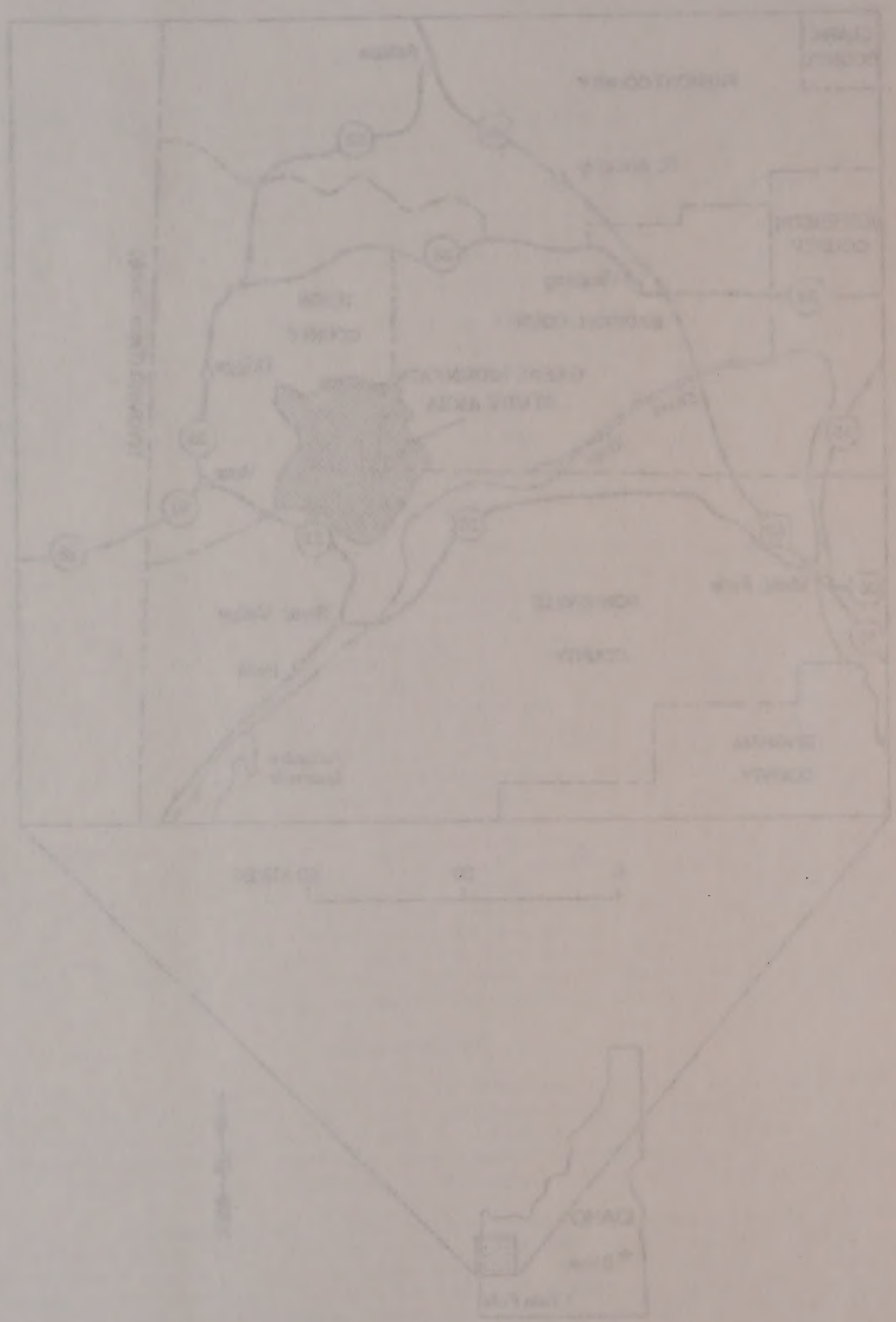


Figure 1.- Location of the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho



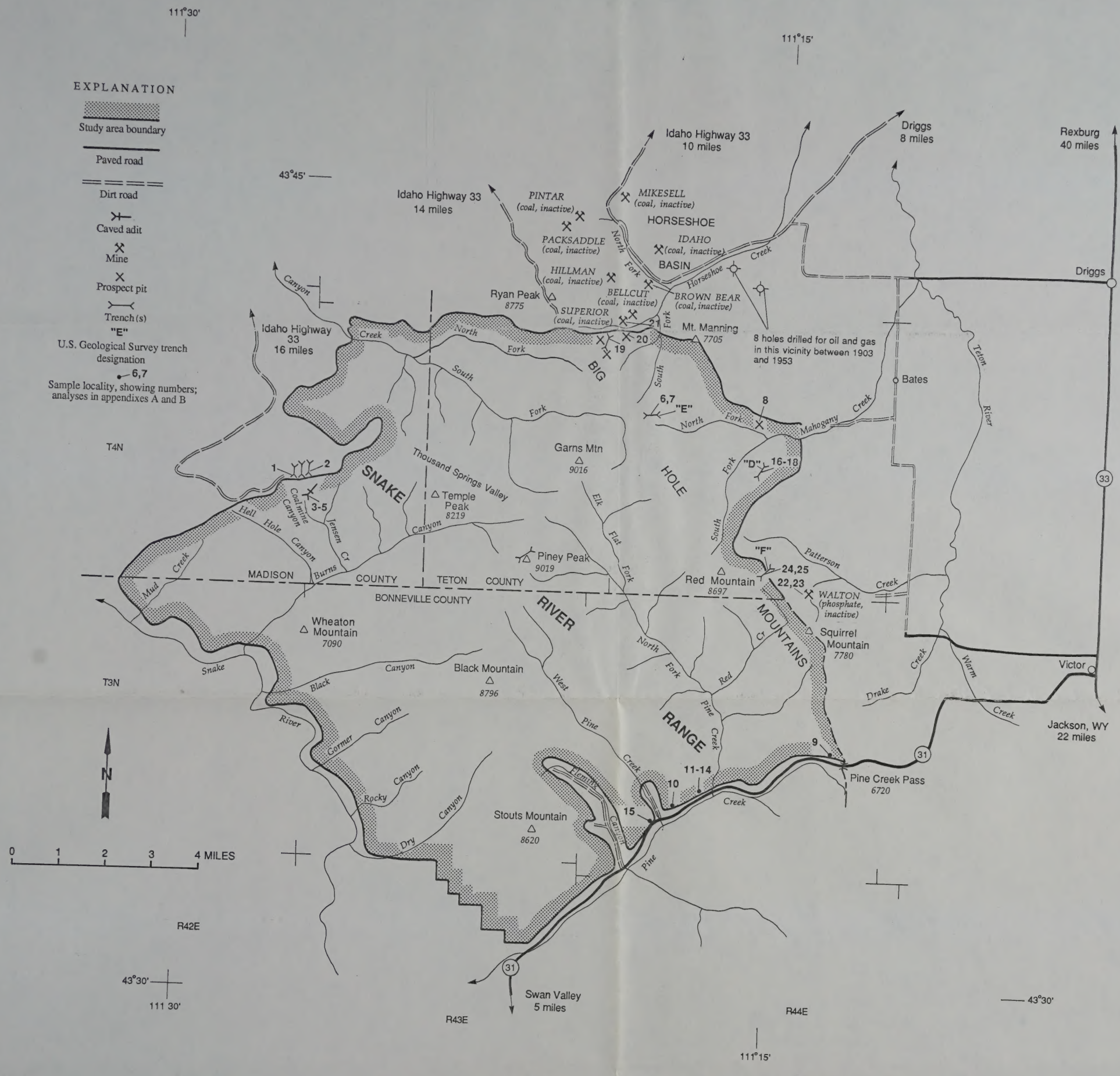


Figure 2.- Mines and prospects in and adjacent to the Garns Mountain study area

111°30'

43°45'

EXPLANATION

Study area boundary

Paved road

Dirt road

Caved adit

Mine

Prospect pit

Trench (s)

"E"
U.S. Geological Survey trench designation

6,7
Sample locality, showing numbers; analyses in appendixes A and B

Idaho Highway 33
14 miles

Idaho Highway 33
16 miles

PINTAR
(coal, inactive)

PACKSADDLE
(coal, inactive)

HILLMAN
(coal, inactive)

BE
(coal,

SUPERIOR
(coal, inactive)

Ryan Peak
8775

Canyon

Creek

North

Fork

South

Fork

BIG

Garns Mtn
9016

Thousand Springs Valley

SNAKE

Temple Peak
8219

Canyon

Elk

Fla

Piney Peak
9019

T4N

1

2

3-5

Coalmine Canyon

Jensen Cr

Hell Hole Canyon

Creek

Mud

MADISON COUNTY

Burns

TETON COUNTY

BONNEVILLE COUNTY

RIVER

Wheaton Mountain
7090

Snake

Black Canyon

Black Mountain
8796

West

T3N

111°15'

Idaho Highway 33
10 miles

Driggs
8 miles

Rexburg
40 miles

43°45'

MIKESELL
(coal, inactive)

HORSESHOE

IDAHO
(coal, inactive)

BASIN

Horseshoe Creek

Fork

BROWN BEAR
(coal, inactive)

LLCUT
inactive)

Mt. Manning
7705

8 holes drilled for oil and gas in this vicinity between 1903 and 1953

Driggs

Bates

Teton River

South Fork

6,7 "E"

North Fork

8

Mahogany Creek

"D" 16-18

HOLE

South Fork

"F"

24,25

22,23

Patterson Creek

Red Mountain
8697

WALTON
(phosphate, inactive)

MOUNTAINS

Squirrel Mountain
7780

North Fork

Red Cr

Drake Creek

Warm

Victor

33

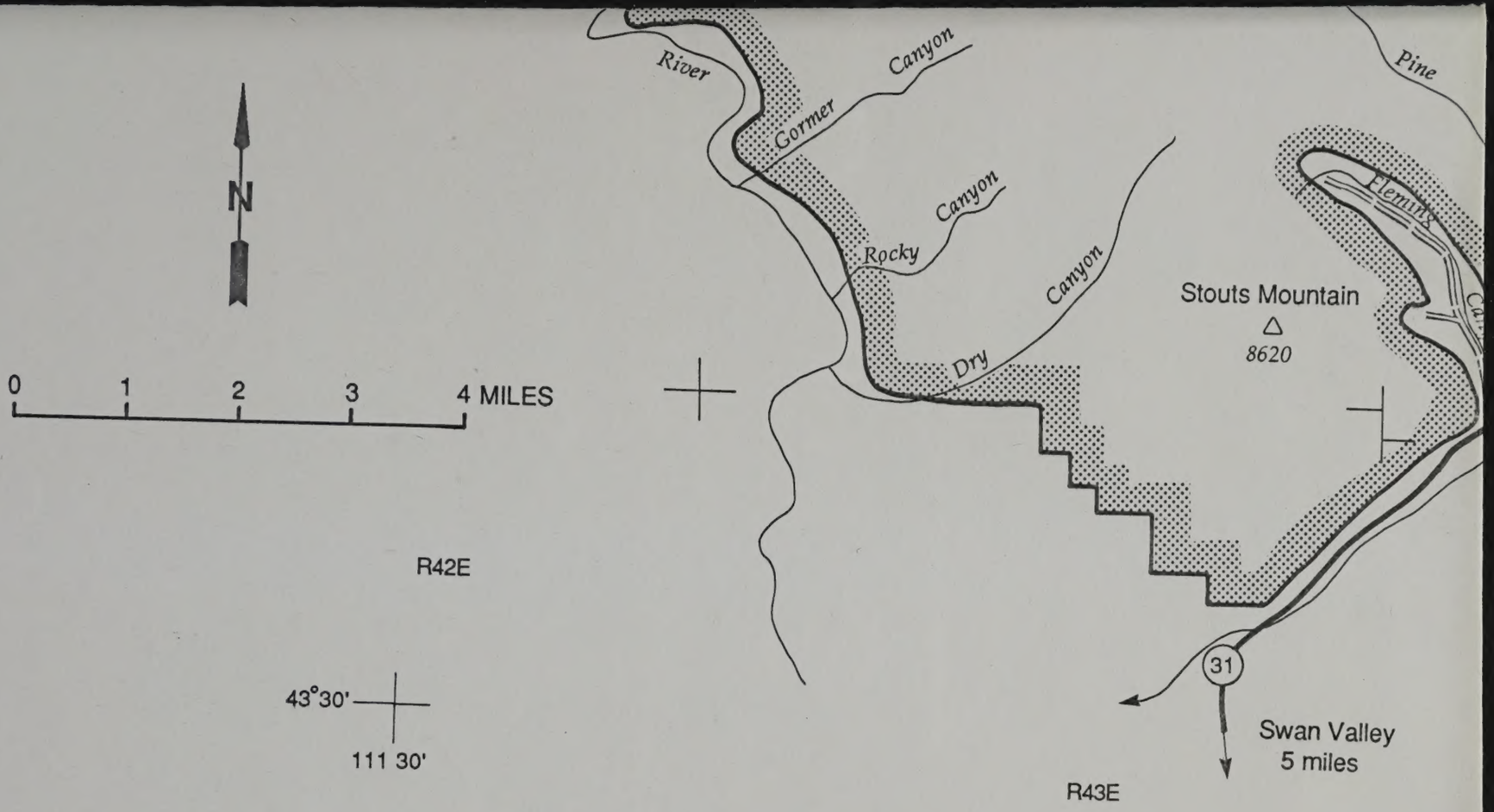
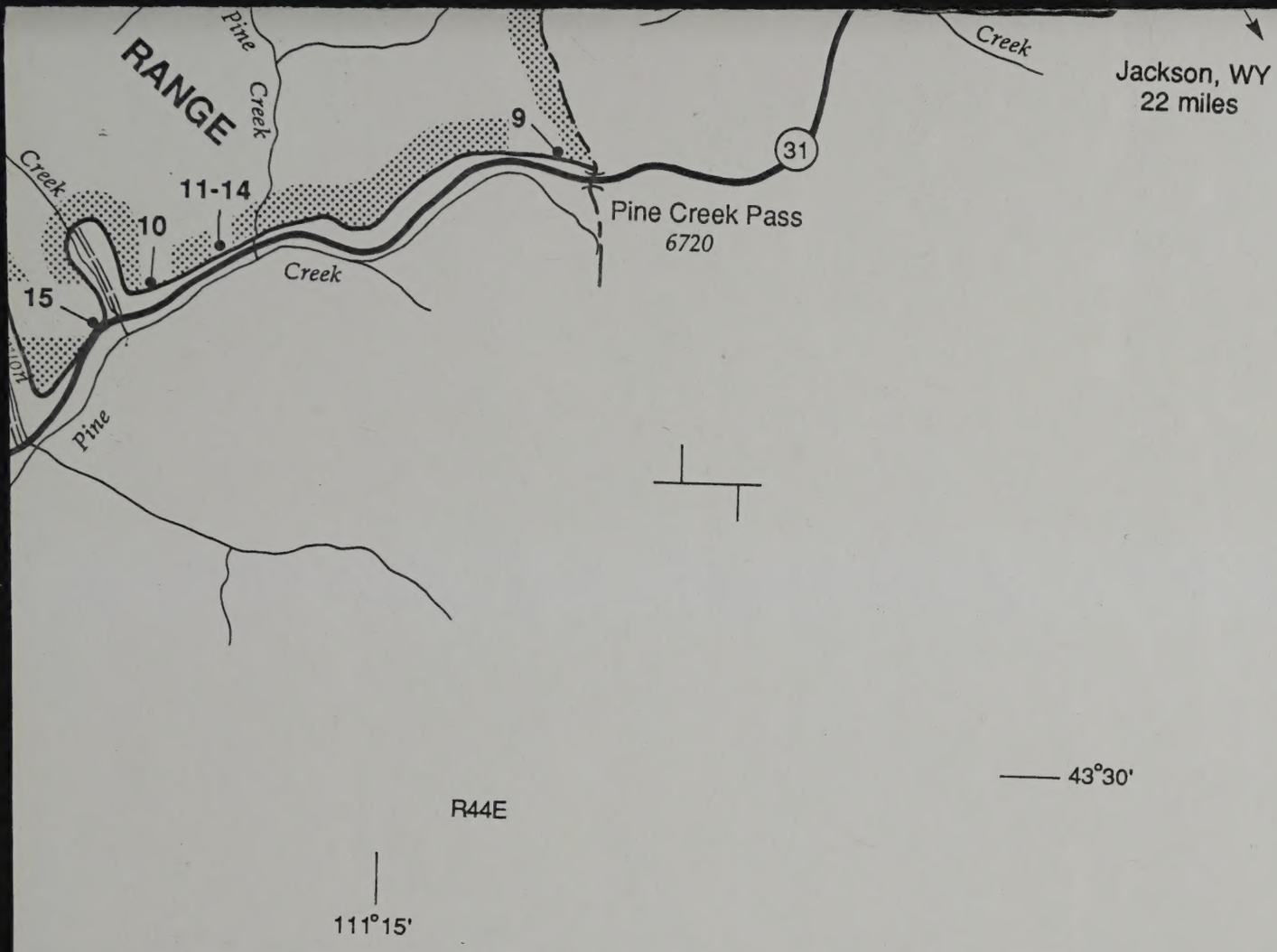


Figure 2.- Mines and prospects in and adjacen



t to the Garns Mountain study area

Rock samples were analyzed for an 11-element[1] geochemical suite using the ICP (inductively coupled plasma) method to detect elements of possible significance, and for gold by fire assay with an atomic absorption finish.

ACKNOWLEDGEMENTS

The authors were provided data on phosphate and oil and gas leases in the study area by Chuck Horsburgh, BLM geologist, Idaho Falls District Office. U.S. Forest Service personnel who were particularly helpful included John Pruess and Jay Benson, Supervisors Office, St. Anthony, Idaho, and Brad Exxon, Driggs District Office, Driggs, Idaho. The Idaho Geological Survey, under the direction of Dr. Earl Bennett, provided geologic maps and minerals data specifically on the Garns Mountain study area.

GEOLOGIC SETTING

The Garns Mountain study area is in the Idaho-Wyoming Overthrust Belt, which is a small part of the larger Overthrust Belt stretching from Alaska to Central American (Maley, 1987, p. 96). The Absaroka and Jackson thrust faults, as well as at least six lesser thrust faults, cross the area. Typical trends are north to northwest with steep southerly dips. These faults are offset by crosscutting, northeast-trending faults (fig. 3). Between thrusts faults, rocks have been folded in tight synclines and anticlines. Chief rock types are siltstones, conglomerates, sandstones, limestones, shales, and quartzites which are in formations ranging in age from Paleozoic to Mesozoic, a span of approximately 500 million years. Total thickness of these formations is more than 11,000 ft. Cenozoic sedimentary and volcanic rocks crop out on the north and west sides of the area (Staatz and Albee, 1966, pl. 1).

Three mineral commodities in the study area are: phosphate rock, coal, and uranium-bearing shale and coal. Phosphate rock is confined to the Permian-age Phosphoria Formation; coal is found mostly in the Cretaceous-age Frontier Formation, and occasionally in the older Bear River Formation; and anomalous amounts of uranium occur in highly faulted, carbonaceous shales of the Phosphoria Formation. Significant concentrations of vanadium, chromium, gallium, and zinc occur locally in the phosphate-bearing and carbonaceous-rich units of the Phosphoria and Frontier Formations.

Four zones, A-D, (A, B, and D are shown on fig. 3), of the phosphate-bearing rocks of the Phosphoria Formation extend discontinuously across the central and northeast portions of the study area. Within the formation, the Meade Peak Member contains the highest phosphate concentrations. The overlying Retort Phosphatic Shale Member has smaller amounts of phosphate; the resistant Rex Chert Member commonly caps the Phosphoria Formation. Measured sections of Phosphoria, which has been subdivided into as many as 23 members, are 115 to 290 ft thick, with the phosphate-bearing Meade Peak Member measuring 9.4 to 63 ft thick (Staatz and Albee, 1966, p. 104-110).

The four, subparallel zones of phosphate-bearing rock trend, in segments, northwesterly from 6 to 15 mi. Approximately 70% of the

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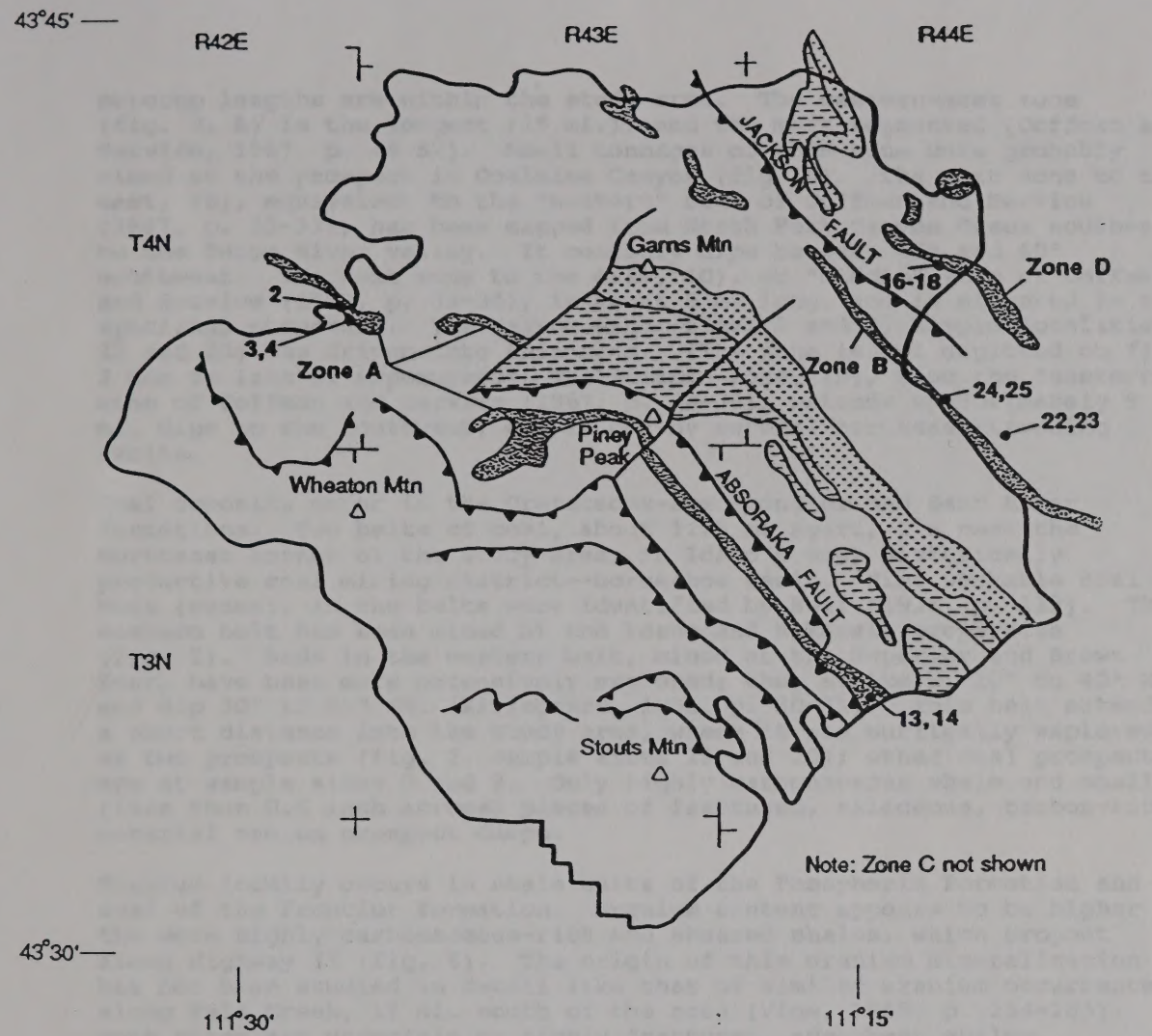
[1]Antimony, arsenic, bismuth, copper, lead, mercury, manganese, molybdenum, silver, tungsten, zinc.



EXPLANATION

Study area boundary

Limestones, shales, siltstones, and conglomerates of various ages

Permian Phosphoria Formation and related rocks; phosphate-bearing rocks

Cretaceous Frontier Formation and Aspen shale; coal-bearing rocks

Cretaceous Bear River Formation

Contact

Major fault

Major thrust fault, sawteeth on downthrown side

2 Locality and sample number containing greater than 10% P_2O_5

N

0 1 2 MILES

Figure 3.- Geologic map of the Garns Mountain study area

outcrop lengths are within the study area. The western-most zone (fig. 3, A) is the longest (15 mi.), and the most segmented (Coffman and Service, 1967, p. 48-52). Small tonnages of this zone were probably mined at the prospect in Coalmine Canyon (fig. 4). The next zone to the east, (B), equivalent to the "western" zone of Coffman and Service (1967, p. 32-33), has been mapped from North Fork Canyon Creek southeast to the Teton River valley. It commonly dips between 45° and 60° southwest. The next zone to the east, (C), or "middle" zone of Coffman and Service (1967, p. 33-34), is about 6 mi long, and is situated in a synclinal structure. The Walton mine (figs. 2 and 3, sample localities 22 and 23) was driven into this zone. (The zone is not depicted on fig. 3 due to lack of exposures.) The eastern zone, (D), also the "eastern" zone of Coffman and Service (1967, p. 34-35), extends approximately 9 mi, dips to the southwest, and is cut by several northeast-trending faults.

Coal deposits occur in the Cretaceous-age Frontier and Bear River Formations. Two belts of coal, about 1.25 mi apart, lie near the northeast corner of the study area, in Idaho's most historically productive coal mining district--Horseshoe Basin. Nine workable coal beds (seams), in the belts were identified by Bell (1918, p. 112). The eastern belt has been mined at the Idaho and Mikesell properties (fig. 2). Beds in the western belt, mined at the Superior and Brown Bear, have been more extensively explored; they strike N. 20° to 40° W. and dip 30° to 85° SW. (Kiilsgaard, 1951, p. 30-31). This belt extends a short distance into the study area, where it was surfically explored at two prospects (fig. 2, sample sites 19 and 20); other coal prospects are at sample sites 8 and 9. Only highly carbonaceous shale and small (less than 0.5 inch across) pieces of fractured, siliceous, carbon-rich material are on prospect dumps.

Uranium locally occurs in shale units of the Phosphoria Formation and coal of the Frontier Formation. Uranium content appears to be higher in the more highly carbonaceous-rich and sheared shales, which cropout along Highway 31 (fig. 5). The origin of this uranium mineralization has not been studied in detail like that of similar uranium occurrences along Fall Creek, 15 mi. south of the area (Vine, 1959, p. 254-283). Both sites are underlain by highly fractured, adsorbent shales. However, Tertiary volcanics, thought to be the source of uranium at the Fall Creek occurrence, were not seen in the vicinity of the Garns Mountain mineralized sites.

Folded and faulted rocks of the Idaho-Wyoming Overthrust Belt may contain subsurface traps or structures for oil and gas. Along the northeast border, the Horseshoe anticline contains rocks of the Frontier Formation and Nugget Sandstone Formation, which have been oil and gas producing units in Wyoming, Colorado, and Montana (Kirkham, 1922, p. 28).

APPRAISAL OF MINERAL COMMODITIES

Resource estimates have been made by the USGS and by earlier USBM investigations for phosphate-bearing rock occurring in the study area, and for coal near the northeast corner of the area. Those estimates are used in this report; field examinations were made to verify previously reported phosphate and coal resources and grades, as well as to analyze mineral commodities for by-product metals. Commodities at individual properties are discussed in the following section. Sample descriptions and analyses are given in appendixes A and B.

Figure 4.--View of phosphate-bearing dump and stockpiles at the Coalmine Canyon mine, looking northeast. Sample nos. 3-5 were collected here.

Figure 5.--View of faulted segments of Phosphoria Formation (Meade Peak Member) shales, limestones, and siltstones along Idaho Highway 31, looking northwest. Samples 9-11 were collected at this location.

Phosphate

Phosphate-bearing shales occur mainly in the Meade Peak Member of the Phosphoria Formation which extends across the area in four zones. The Meade Peak Member is overlain by the Retort Phosphatic Shale Member, which contains lesser amounts of phosphate, and the Rex Chert Member. Staatz and Albee (1966, p. 32-37) and Gardner (1944, p. 25-29) have described numerous thin beds in the Meade Peak Member. Commonly, thin phosphate-bearing beds of high- to medium-grade occur in the basal 15 to 20 ft of the member, with low-grade beds in the center, and some thin, high-grade beds in the upper 5 ft of the section. Also, the Retort Member has high-grade phosphate in thin beds usually near its base. To ensure that these four zones, and other phosphate areas in the region, would be available for mining purposes in the future, the USGS designated tracts of land underlain by the four zones as phosphate leasing areas in 1965. USBM engineers (Coffman and Service, 1967, p. 37 and 52) estimated that the four zones contained 528 million tons of phosphate rock with a grade of plus 10% P_2O_5. Approximately 70% of this amount is within the study area.

The western zone (fig. 3, A) of phosphate-bearing shale of the Phosphoria Formation is approximately 15 mi long (12 mi in the study area) in the central part of the study area. This zone, lying west of the Absaroka thrust, is mapped as the thickest and the most segmented of the four zones (Staatz and Albee, 1966, pl. 1, and Coffman and Service, 1967, p. 49-52). It is traceable north of the area and extends southeasterly to outcrops along Idaho Highway 31, at samples sites 11-14 (fig. 2). Zone segments trend northeast to east-west, and dips are usually between 40° and 60 southeast to south.

Based on stockpiled material at sample sites 3 and 4 (figs. 2 and 4), the Meade Peak Member of the western zone was probably mined in this caved adit, which had an estimated 500 ft of workings. The zone, at sample sites 1 and 2, was dozed by prospectors on Idaho Government Phosphate Lease No. 09704, circa. 1958 (Staatz and Albee, 1966, p. 105). The USGS did additional dozing in this vicinity, and dug two trenches in the Retort and Meade Peak Members on the west slope of Piney Peak in 1963 (Coffman and Service, 1967, p. 51). In 1978, a phosphate prospecting application permit for Lease No. I-14711 was issued for the vicinity of Coalmine Canyon; the case was closed in 1989.

The western (A) zone contains an estimated total of 270.3 million tons of phosphate-bearing rock which average over 10% P_2O_5 (Coffman and Service, 1967, p. 52). Of this total, 23.5 million tons average greater than 31% P_2O_5; 66.2 million tons average 24% to 31% P_2O_5; 81.3 million tons average 18% to 24% P_2O_5; and 99.3 million tons have 10% to 18% P_2O_5. Five of nine samples (fig. 2 and appendixes A and B, nos. 1-5 and 11-14) taken of zone material during this investigation contain more than 10% P_2O_5, and as much as 3280 ppm (0.33%) vanadium, 3950 ppm (0.40%) chromium, 20 ppm (0.002%) gallium, and 3610 ppm (0.36%) zinc.

Prominent exposures of the B zone were trenched and sampled in 1944 by the USGS; they deepened and resampled the trenches in 1963. During the present USBM investigation, samples 6, 7, 24, and 25 (fig. 2) were collected from USGS-designated trenches "E" and "F" (fig. 6). The zone trends northwest and dips 35°-65° SW. Coffman and Service (1967, p. 37) calculated a total of 115.3 million tons of phosphate rock for the western trend (zone B). Of this total, 19.4 million tons contain more than 24% P_2O_5; 42.6 million tons average 18% to 24% P_2O_5; and 53.3 million tons average 10% to 18% P_2O_5. Samples 24 and 25, collected in

trench "F", contain over 37% P_2O_5, the highest phosphate content of samples taken during this investigation.

The C zone, the syncline structure of Coffman and Service (1967, p. 33 and 34), extends about 6 mi north from the Teton River valley to South Fork Mahogany Creek. It lies between zones B and D, but is not shown on figure 3 due to lack of exposures. Small tonnages of phosphate were probably mined at the Walton mine (figs. 2 and 3, samples 22 and 23). Judging by dump sizes, the adit was driven a few hundreds of feet to the southwest. Coffman and Service (1967, p. 37) estimated 61.5 million tons averaging over 10% P_2O_5 occur in the zone. Of this total, 14.3 million tons is over 24% P_2O_5; 23.6 million tons has from 18% to 24% P_2O_5, and a like tonnage averages from 10% to 18% P_2O_5. Of the two USBM samples taken from the dump, no. 23 contained the highest metal values: 17.70% P_2O_5, 2450 ppm (0.25%) vanadium, 2560 ppm (0.26%) chromium, 14 ppm (0.0014%) gallium, and 5440 ppm (0.54%) zinc.

The eastern zone, (D), extends approximately 9 mi in a northwest direction near the northeast corner of the study area (fig. 3). USGS trench "D" (fig. 7) is near the center of the zone, which dips 20° to 60° southwesterly. Crossfaulting, valley alluvium, and dense vegetation have made this zone difficult to trace. Coffman and Service (1967, p. 37) estimated that the eastern trend (zone D) contained 80.9 million tons of phosphate rock averaging more than 10% P_2O_5. About 19.5 million tons average plus 24% P_2O_5; and the remaining 61.4 million tons are equally divided between grades of 18% to 24% and 10% to 18% P_2O_5. Samples 16-18 (fig. 2), taken of zone D material, contain between 19.30% and 34.30% P_2O_5, as well as maximum concentrations of: 1520 ppm (0.15%) vanadium, 18 ppm (0.0018%) gallium, 2520 ppm (0.25%) zinc, and 2050 ppm (0.21%) chromium.

Coal

Coal mines near the study area's northeast corner have yielded approximately 100,000 tons of low ash-and-sulfur coal, with Btu ratings between 11,000 and 14,000 (Kiilsgaard, 1951, p. 32), excellent for heating. These mines are in the Horseshoe Basin mining district which has an estimated 11 million tons of coal resources (Evans, 1924, p. 11). However, only carbonaceous and fissile shale, and small amounts of highly fractured, poor-quality coal-like material, were found at four sample localities during the current study. Samples 19 and 20 (fig. 2) were taken at the Nickell's and Keystone prospects (Kiilsgaard, 1951, fig. 2); colluvium and dense vegetation obscured outcrops and workings. At sample locality 19, two small prospect pits and a trench 25 ft long, 4 ft wide, and 2 ft deep, contain broken pieces of poor-quality coal on dumps. No workings were found in the vicinity of the Keystone, but a sample (no. 20) was collected of small pieces of weathered and fractured coal from the remains of a shipping or loading pile. Sample 21 (fig. 8), taken in the collar of the main shaft of the Superior mine (fig. 2), was the best coal outcrop found near the area.

A coal prospect at Pine Creek Pass (fig. 2, sample 9) was worked prior to 1917, and reopened in that year (Mansfield, 1920, p. 134). He reported that the coal bed strikes N. 55 W. and dips 55° SW.; it was about 2 ft thick and contained much clay. A sample taken by him had a high moisture and ash content, and a low heating value of 7,376 Btus. A shallow dozer cut has exposed fissile, carbonaceous shale, which contained no anomalous metal values; coal was not found at the prospect.

A small prospect pit at sample locality 8 (fig. 2), near the Mahogany-North Fork Mahogany Creek confluence, has carbonaceous siltstone exposed

Figure 6.--View of Trench "F" dug by USGS in 1944, on ridge between Red and Patterson Creeks, looking southeast. Squirrel Mountain, in center of photo; dark green vegetation indicates areas underlain by phosphate-bearing rock. Samples 24 and 25 were from trench.

Figure 7.--View of Trench "D" on hillside east of South Fork Mahogany Creek, looking northeast; trench dug across phosphate-bearing beds by USGS in 1944; Teton River valley in background. Samples 16-18 were taken from the trench.

Figure 8.--View of coal seams, separated by siltstone, in collar of the Superior mine, Horseshoe Basin mining district. Mine is adjacent to the study area border.

in its walls. No coal was noted in the sample, which contained no anomalous amounts of metals.

Uranium

Uranium minerals occur in highly faulted, carbonaceous and phosphate-bearing shale and coal in and near the study area. Scintillometer readings of 40 to 60 cps (counts per second) are background for these rock units in the area. At sample localities 10 and 11-14, readings range from 120 to 420 cps; sample 14 had the highest U_3O_8 content, 0.016%. Vine (1959, p. 283) obtained four samples near Pine Creek Pass and two samples from the Horseshoe district. These samples assayed as much as 0.003% U_3O_8.

Oil and Gas

The Idaho-Wyoming Overthrust Belt has been explored for oil and gas by drilling since 1903. The Frontier and Nugget Sandstone Formations, oil- and gas-bearing units in the region, have been folded into anticlines and synclines, and faulted, in and near the study area. A ten-year oil and gas lease was held by Meridian Oil Production for tracts of land east of Piney Peak in the central portion of the study area; no holes were drilled, and the lease expired in February 1992.

Eight holes have been drilled to explore the Horseshoe Basin anticline, lying east of the study area. The holes were drilled intermittently from 1903 to 1980 to depths of between 100 ft. and 12,720 ft. Drill logs indicate only minor shows of oil and gas; all holes have been plugged and abandoned.

CONCLUSIONS

Approximately 95% of all phosphate mined in the world is used to make fertilizer. Phosphate demand is expected to increase to keep pace with anticipated world population gains. Presently, phosphate reserves in Florida, North Carolina, and elsewhere in southeast Idaho supply the nation's demand; however, as these reserves are depleted, resources in the study area are likely to be considered mineable. The average mill feed for phosphate in the western states was 22.2% P_2O_5 in 1986 (U.S. Bureau of Mines, 1987, p. 218). Although many samples of area phosphate beds are of higher P_2O_5 content, the beds are usually thin and steeply dipping, thus subject to dilution and necessitating some expensive underground mining.

The coal beds in the Horseshoe Basin mining district extend a short distance into the study area. The tonnage and quality of coal in the area appears to be insufficient to justify exploration in the near future.

Uranium content in carbonaceous and phosphate-bearing shales and coal is locally high, but overall radioactivity in these units is probably too low to be recovered. The shales also contain other significant amounts of metals such as zinc, chromium, vanadium, and gallium. However, the metal concentrations would have to be a factor 20 times higher, in one of the metals or in combination of them, to be considered economic.

Oil and gas resource studies were beyond the scope of this report, but extensive investigations have been conducted by others. Sandberg (1983, p. F5) places a medium potential for oil and gas in the study area, based on geology, structure, and drill hole data.

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Appendix A.-- Descriptions and analyses of rock samples from the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho

[Au, gold; Ag, silver; As, arsenic; Bi, bismuth; Cu, copper; Hg, mercury; Mn, manganese; Mo, molybdenum; Pb, lead; Sb, antimony; W, tungsten; Zn, zinc]

[NA, not applicable; <, less than; --, not analyzed]

Sample no.	Figure no.	Sample type	Length (ft)	Description	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Sb (ppm)	W (ppm)	Mn (ppm)	Bi (ppm)	Mo (ppm)	Hg (ppb)
1	3	Select	NA	Carbonaceous, siliceous shale from dozer cut	--	<0.2	10	9	22	8	<5	<10	9230	<5	5	20
2	2,3	Do	NA	Siliceous shale with fossil fragments from dozer cut	--	0.5	22	128	1360	33	<5	20	642	<5	8	95
3[1/]	2,3	Do	NA	Small oolites in phosphate-bearing shale, from 10-ton stockpile	45	18	402	10	3385	60	35	55	46	<5	87	405
4	2,3	Do	NA	Oolitic, phosphate-bearing shales in lumps, from same stockpile as sample 3	<5	1.6	49	9	638	6	<5	15	101	<5	7	130
5[1/]	3	Chip	6.0	Across siliceous shale with minor amounts of fossil fragments	10	9.4	112	15	3610	45	36	65	123	<5	220	25
6	3	Grab	NA	Siliceous, carbonaceous shale, from USGS-dug trench	--	<0.2	7	16	226	5	<5	<10	165	<5	2	20
7	3	Select	NA	Siliceous shale with some fossil remains, same trench as sample 6	--	<0.2	8	40	107	<5	<5	<10	92	<5	2	20
8	3	Chip	2.0	Across siltstone and clay in small pit	5	0.2	17	12	113	15	<5	<10	267	<5	4	165
9	3	Do	1.0	Across weathered, fissile shale	<5	<0.2	16	19	87	6	<5	<10	120	<5	1	25
10	3	Do	5.5	Do..	<5	1.8	58	195	575	18	<5	13	518	<5	14	120
11[1/]	3	Do	19.0	Across fissile shale with siliceous and carbonaceous nodules	7	8.5	92	16	1990	22	20	30	210	<5	58	230

Appendix A.-- Descriptions and analyses of rock samples from the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho--Continued

Sample no.	Figure no.	Sample type	Length (ft)	Description	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Sb (ppm)	W (ppm)	Mn (ppm)	Bi (ppm)	Mo (ppm)	Hg (ppb)
12[1/]	3	Chip	2.0	Across fissile shale with limestone and siltstone nodules, and some fossil fragments	6	8.4	103	12	1725	14	22	26	115	<5	57	95
13[1/]	2,3	Do	2.0	Across fissile shale with oolites and fossil fragments	5	6.1	73	17	1280	17	12	17	40	<5	92	130
14[1/]	2,3	Do	1.0	Across carbonaceous shale with small oolites and fossil remains	<5	23	238	22	1760	26	32	28	29	<5	115	85
15	2,3	Random chip	10.0	Across gray, massive limestone with interbedded siltstone	<5	<0.2	9	14	87	8	<5	<10	1460	<5	2	15
16[1/]	2,3	Select	NA	Oolite-rich, phosphate-bearing shale in USGS-dug trench	6	1.1	35	9	270	17	5	10	36	<5	8	40
17	2,3	Chip	2.0	Across oolite-rich zone in trench at sample site 16	5	18	185	14	2360	20	28	45	198	<5	58	50
18[1/]	2,3	Select	NA	Black, phosphate-bearing shale, same sample site as 16 and 17	8	20	193	20	2520	23	30	42	203	<5	60	55
19	3	Do	NA	Black carbonaceous shale	12	0.2	8	7	52	5	<5	<10	20	<5	<1	180
20	3	Do	NA	Highly weathered, poor-quality coal	<5	<0.2	5	8	32	<5	<5	<10	15	<5	1	25
21	3	Chip	2.0	Across two coal seams in collar of caved shaft	<5	<0.2	4	2	14	<5	<5	<10	50	<5	1	20
22[1/]	2,3	Grab	NA	Oolitic, phosphate-bearing shale on upper dump	150	10	174	15	4035	38	32	65	110	<5	158	35

Appendix A.-- Descriptions and analyses of rock samples from the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho--Continued

Sample no.	Figure no.	Sample type	Length (ft)	Description	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Sb (ppm)	W (ppm)	Mn (ppm)	Bi (ppm)	Mo (ppm)	Hg (ppb)
23[1/]	2,3	Grab	NA	Oolitic, phosphate-bearing shale on lower dump	8	21	208	25	5440	36	30	113	108	<5	103	325
24[1/]	2,3	Chip	3.0	Across black, phosphate-rich shale with oolites and fossil fragments from trench	5	2.6	27	7	63	5	5	12	10	<5	8	95
25[1/]	2,3	Select	NA	Black, oolitic, calcareous shale with fossil fragments, from 500-lb stockpile	<5	3.4	37	6	870	9	5	15	12	<5	16	60

1/ Additional significant analyses: (Analytical method was lithium metaborate fusion-ICP analysis)

Sample no. 3 - 3950 ppm chromium; 1065 ppm vanadium; 102 ppm uranium
5 - 1005 ppm chromium; 1930 ppm vanadium; 108 ppm uranium
11 - 1105 ppm chromium; 1135 ppm vanadium
12 - 1310 ppm chromium; 1325 ppm vanadium
13 - 1320 ppm chromium
14 - 2675 ppm chromium; 3280 ppm vanadium; 160 ppm uranium
16 - 108 ppm uranium
18 - 2050 ppm chromium; 1520 ppm vanadium; 112 ppm uranium
22 - 2325 ppm chromium; 1225 ppm vanadium; 125 ppm uranium
23 - 2560 ppm chromium; 2450 ppm vanadium
24 - 148 ppm uranium
25 - 147 ppm uranium

Appendix B.-- Descriptions and whole-rock analyses of samples from the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho

[Al_2O_3, aluminum oxide; CaO, calcium oxide; Fe_2O_3, iron oxide; K_2O, potassium oxide; MgO, magnesium oxide; MnO, manganese oxide; P_2O_5, phosphate oxide; NaO, sodium oxide; SiO_2, silicon oxide; TiO_2, titanium oxide; LOI, loss on ignition; all concentrations in weight %; NA, not applicable]

Sample no.	Figure no.	Sample type	Length (ft)	Description	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI
1	3	Select	NA	Carbonaceous, siliceous shale from dozer cut	56.20	7.85	2.95	2.48	13.10	1.63	1.85	0.60	0.20	1.25	12.25
2	2,3	Do	NA	Siliceous shale with fossil fragments from dozer cut	47.85	.97	6.20	.21	20.75	.35	.24	.05	21.10	.14	2.10
3	2,3	Do	NA	Small oolites in phosphate-bearing shale, from 10-ton stockpile	20.05	3.85	3.12	1.30	26.60	.39	1.05	.20	15.20	.013	27.25
4	2,3	Do	NA	Oolitic, phosphate-bearing shale in lumps, from same stockpile as sample 3	2.15	.28	.23	.47	50.15	.48	.10	.02	23.80	.015	22.30
5	3	Chip	6.0	Across siliceous shale with minor amounts of fossil fragments	28.50	4.45	1.92	5.16	21.60	.41	1.27	.31	9.25	.018	25.35
6	3	Grab	NA	Siliceous, carbonaceous shale, from USGS-dug trench	82.35	.63	.54	.28	7.62	.08	.25	.05	1.36	.025	5.60
7	3	Select	NA	Siliceous shale with some fossil fragments, same trench as sample 6	77.80	1.56	1.23	.23	7.95	.20	.61	.07	5.85	.014	3.40
8	3	Chip	2.0	Across siltstone and clay in small pit	62.15	8.25	2.18	2.63	9.86	.10	1.78	.35	.65	.038	11.05
10	3	Do	5.5	Across weathered, fissile shale	49.40	8.50	3.02	2.95	12.20	.69	2.63	.41	7.65	.071	11.50
11	3	Do	19.0	Across fissile shale with siliceous and calcareous nodules	38.15	6.23	1.87	5.70	16.85	.85	2.10	.39	5.82	.032	21.90

Appendix B.-- Descriptions and whole-rock analyses of samples from the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho--Continued

Sample no.	Figure no.	Sample type	Length (ft)	Description	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI
12	3	Chip	20.0	Across fissile shale with limestone and siltstone nodules, and some fossil fragments	33.10	5.52	1.58	5.35	19.70	.42	1.83	.34	8.05	.017	24.10
13	2,3	Do	2.0	Across fissle shale with oolites and fossil fragments	12.25	1.50	1.18	.44	46.10	1.02	.56	.13	27.20	.006	10.25
14	2,3	Do	1.0	Across carbonaceous shale with small oolites and fossil remains	31.80	4.63	2.35	.82	20.10	.67	1.53	.35	14.80	.005	22.60
15	2,3	Random chip	10.0	Across gray, massive limestone with interbedded siltstone	40.65	4.25	1.78	4.25	25.20	.79	1.31	.33	.78	.023	21.05
16	2,3	Select	NA	Oolite-rich, phosphate-bearing shale in USGS-dug trench	9.20	.72	1.05	.18	52.00	.68	.23	.07	34.30	.004	2.62
17	2,3	Chip	2.0	Across oolite-rich zone in trench at sample 16	11.50	.25	.17	.87	50.30	.72	.12	.02	32.25	.003	4.85
18	2,3	Select	NA	Black, phosphate-bearing shale, same sample site as 16 and 17	24.15	4.60	1.64	1.95	27.25	.15	1.10	.22	19.30	.027	18.75
22	3	Grab	NA	Oolitic, phosphate-bearing calcerous shale on upper dump	19.15	4.12	1.52	2.51	30.25	.66	1.15	.21	17.70	.017	22.10
23	2,3	Grab	NA	Oolitic, phosphate-bearing shale on lower dump	25.70	4.90	2.01	3.83	20.85	.58	1.60	.27	10.95	.018	28.05

Appendix B.-- Descriptions and whole-rock analyses of samples from the Garns Mountain study area, Bonneville, Madison, and Teton Counties, Idaho--Continued

Sample no.	Figure no.	Sample type	Length (ft)	Description	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI
24	2,3	Chip	3.0	Across black, phosphate-rich shale with oolites and fossil fragments from trench	14.65	0.32	0.18	0.08	44.20	0.54	0.08	0.01	37.60	.002	2.75
25	2,3	Select	NA	Black, oolitic, calcareous shale with fossil remains, same site as sample 24	9.80	.20	.17	.09	50.15	.70	.05	.01	37.30	.003	2.42

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